Report on the
EBS pollock Stock Assessment and Management Methods

Prepared for:
The Center for Independent Experts

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EXECUTIVE SUMMARY

The review of EBS pollock, held at the Alaska Fisheries Science Center, Seattle, was very wide in scope, covering data inputs, stock assessment, regional and pollock-specific harvest strategies, and ecosystem issues. Arguably, the scope was too wide for any one element to receive appropriate attention. It is recommended that future reviews are more focused on specific issues, and that clear context for specific terms of reference is provided. More thought needs to be given to allowing for in-depth discussion and real-time analysis rather than wide review of multiple topics.

A number of recommendations are made with respect to each term of reference (highlighted in **bold, red** throughout the text), dealing in turn with data inputs; knowledge of biology; stock assessment; the harvest strategy used by the North Pacific Fishery Management Council; and the appropriateness of the harvest strategy within an ecosystem context. No single comment or recommendation is such that concern should be raised as to the quality of the science, or to question whether the best scientific information is available for decision making purposes. The recommendations generally point to possible work which at a minimum should clarify issues and provide greater confidence as to the utility of information provided.

There is, however, a concern that the harvest strategy in place (the combination of data flows, assumptions, assessment, and harvest control rules) may not be fully robust to an over-ride in place to protect pollock as forage for sea lions. That over-ride may or may not be triggered in coming years. Overall, therefore, while there remains a need to review in greater detail the stock assessment *per se*, it is recommended that the priority for work should be to undertake management strategy evaluation of the performance of the current harvest strategy, especially in response to potential changing data availability triggered by the sea lion over-ride rule. In carrying out that work, some of the issues raised relating to the assessment can in any case be considered.

BACKGROUND

Eastern Bering Sea (EBS) Pollock

Walleye pollock (*Theragra chalcogramma*) is distributed throughout the North Pacific region, with the major concentration in the Eastern Bering Sea (EBS). EBS pollock is one of the world's major industrial fisheries, providing a large proportion of global whitefish production. EBS pollock production is therefore important commercially within Alaska but also as a global driver of whitefish markets and prices. Pollock is an important component of the EBS ecosystem and there is concern about stock size (and structure and distribution) within the multispecies fisheries context, and as specific forage for endangered species, most notably Steller sea lions. Although the EBS pollock is a relatively "clean" fishery, there is also concern about bycatch of other species, most notably Chinook and Chum salmon.

EBS pollock has been fished since the late 1950s. Since the US EEZ was declared in 1977, annual catches have been of the order of 1.2 million tones, with catches of close to 1.5 million tonnes in the early to mid 2000s, declining sharply in 2008 to 1 million tones, 815,000 tonnes in 2009 and expected catches in 2010 of a similar order (see text figure copied from 2009 SAFE Report). These recent catches are the lowest for more than 20 years, reflecting a period of poor recruitment and consequently diminishing stock size.

Figures

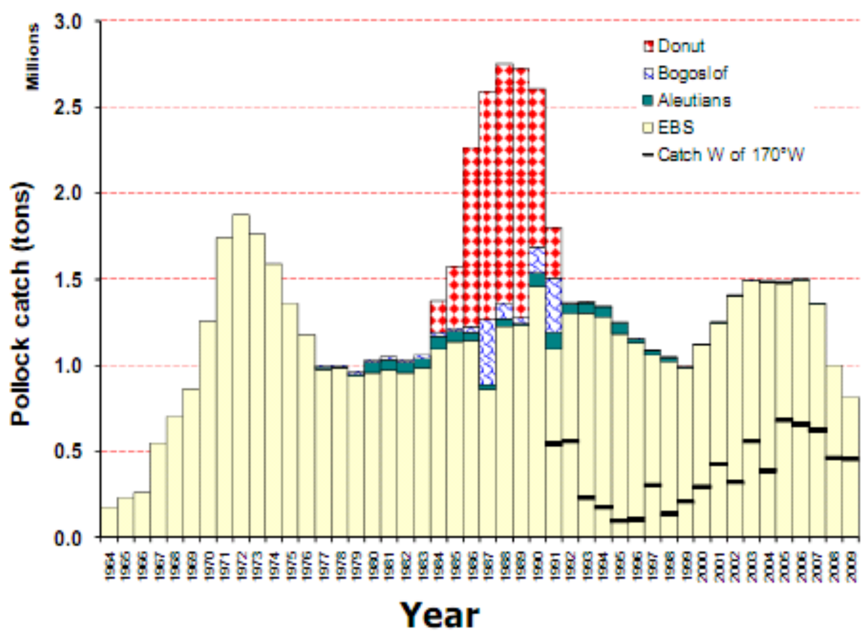


Figure copied from 2009 SAFE Report, showing Alaska Pollock catches for various regions from 1964 to 2009. The 2009 catches are based on the then (2009 SAFE Report) expected 2009 catch totals.

The fishery traditionally has two seasons, so-called A and B Seasons. The A season runs from mid January to mid April and targets spawning fish for highly valued roe. A Season fishing is concentrated relatively near shore in the southwest region of the EBS (north and west of Unimak Island and, depending on ice conditions, the Pribilof Islands). The B Season, or summer fishery, runs from early June through to late October and targets a wider age range of fish, including juveniles, and extends over the EBS region. In recent years the B Season fishery has tended to the northwest, a departure from the fishing pattern since 1991. However, the recent pattern is not dissimilar to earlier fishing patterns. The change in pattern may reflect environmental changes but this is unclear.

The EBS pollock fishery is well monitored by international standards, with 100% or 200% observer coverage on larger vessels and 30% coverage on smaller vessels (although this will also be increased to 100% from 2011 as part of salmon bycatch management arrangements). Age and biological information is extensive. Fishery independent information is available from an annual, general purpose bottom trawl survey and a (mostly) biennial dedicated acoustic (or "echo integration") survey. A statistical catch at age model is fit to data from these sources and is used to estimate various MSY-related reference points used in a harvest control rule.

Advice on EBS pollock allowable catches is provided using the "Tier" system developed for use by the NPFMC (Amendment 44/44, June 1996). EBS pollock is one of a few fisheries where catch advice is developed using Tier 1. Tier 1 is the highest Tier in the system and is used for stocks where the information/assessment is able to provide a reliable point estimate of biomass, B, and B_{MSY} and a reliable *pdf* of F_{MSY}. Currently, as B is estimated to be below B_{MSY}, the relevant Tier 1 harvest control rule is Tier 1b.

Of particular interest at this time, is the probability of the EBS pollock stock being or expected to be below $B_{20\%}$, a trigger point for declaration of no directed pollock fishing to protect Steller sea lions. The trigger point arrangements exist as "reasonable and prudent measures" under the Endangered Species Act; it is not part of the Tier system or any other implementing tool under fisheries legislation.

The Tier system generates Overfishing Limits (OFL) and Allowable Biological Catches (ABC). These are evaluated during the stock assessment and by the stock assessment Plan Team which coordinates development of the SAFE Report containing summary information on a wide range of stock assessments. The SAFE Report is considered by the NPFMC Council SSC which provides advice on TAC setting to the Council. The Council decides on TACs which are then formally set by the Secretary of Commerce following appropriate consultation. TACs cannot exceed the ABC. Although the Council system is in essence a cooperative one with the Council acting as primary advisor to the Secretary, it is possible for an over-ride where other provisions are triggered. For example, as noted above, to ensure sufficient forage availability for Steller sea lions, regardless of the calculation of OFL and ABC using the Tier 1 harvest control rule, the directed catch for EBS pollock would be set to zero if $B < B_{20\%}$. In this case, the Regional

Administrator is obliged to order cessation of directed fishing for EBS pollock. A similar declaration would be triggered if salmon bycatch were to exceed in-season limits for Chinook and Chum salmon due to come in to effect in 2011.

REVIEW PROCESS

The review of EBS pollock took place at the Alaska Fisheries Science Center (AFSC), Seattle, Washington, from 28th June to 2nd July 2010. The review was hosted by AFSC. No Chair was notified in advance and the review panel was not tasked to provide a group report. Anne Hollowed from the AFSC acted as an informal Chair and the CIE reviewers worked collaboratively although each will provide an independent report. Notification of the meeting and dissemination of papers followed closely the schedule laid out in the Statement of Work (see Appendix 2). Materials were provided in advance *via* a website set up for the purpose (see Appendix 1). Overall, administration of the review seems to have been sound.

Participants in the review are listed in Appendix 3. Participants were primarily from the various AFSC groups with involvement on EBS pollock. Two NPFMC Council representatives were present, as were a limited number of industry and environmental group representatives. I am not aware of any problems with notification of the meetings and interpret from the presence of stakeholder representatives, and lack of complaint, that notification was appropriate. All participants were able to participate throughout the meeting and opportunity was explicitly given for input. The majority of "other participants" contributed usefully to discussion and I believe that all were provided appropriate opportunity for involvement.

The Terms of Reference (ToR) for the review are given in Appendix 2, Annex 2. Generally, CIE reviews focus on a particular phase of the stock assessment process – either the data inputs or the assessment *per se*. The ToR set for this review is very wide, spanning all data inputs and methods, the stock assessment, harvest strategies used in the North Pacific region and even wider ecosystem management considerations. Given the scope of the ToR, it was not possible to devote as much time as would be desirable to any one issue area, especially the stock assessment but also the surveys and evolving work on opportunistic data collection. At the risk of it sounding like a complaint, some statistics are perhaps worth noting. Nineteen (19) presentations were given, comprising in excess of 600 slides. Allowing a modest 2 to 3 minutes presentation time *per* slide (many required much more), that translates to 20 to 30 hours of presentations. As the main review meetings took place over three days, this translates effectively to the entire time taken by presentation, leaving little for in-depth discussion and potential analysis.

Given the EBS pollock stock assessment has not been the subject of CIE review since 2000 it would perhaps have been useful to spend the whole review period on a detailed examination of the stock assessment itself. However, it is notable that whilst the CIE has not been involved in EBS stock assessment review since 2000, a useful and high quality partial review of the assessment was carried out on behalf of Greenpeace in 2009. That review was useful in this process. The AFSC provided detailed stock assessment materials, including ADMB code, as input to the Greenpeace review. It is also notable that with respect to the ToRs relating to harvest strategy and ecosystem considerations (ToR d and e respectively), an extensive report commissioned by the NPFMC in 2002 was available to the CIE reviewers. That report essentially considered the same issues as raised by the ToR.

Terms of Reference of course set out the tasks for review. It is always helpful, however, to have a clear context, or purpose, laid out to help interpret review requirements. For example, is the review a *pro forma*, scheduled exercise or is there a motivating factor for the review at the particular time. No context for the EBS pollock review was provided and the reviewers were essentially left to interpret requirements. Given the scope of the ToR this was unhelpful. At the outset, the reviewers jointly discussed with Anne Hollowed and Jim Ianelli of the AFSC to clarify the AFSC needs. It emerged that there were no specific drivers for the review at this time and that it was in effect "the turn of EBS pollock". The AFSC desired outcome was for independent and free-ranging input on the various matters raised in the ToR, with clear recommendations where appropriate. The particular outcome sought was for "constructive input". The review was conducted in this light.

The lack of pre-specified context, and wide ToR, were reflected somewhat in the presentations made. A total of nineteen presentations (see appendix 1) were given in the first three days of review. Presentations were somewhat general in nature and it was not always clear how specific presentations would help attend to each ToR. This approach (large number of presentations taking considerable time, and lack of focus) was not the most efficient way of proceeding. Given the wide scope of the ToR it mitigated against in-depth review on any given issue. It should be noted, however, that AFSC staff were clearly very open and willing to participate and that presentations were of a high standard.

It is **recommended** that future reviews are more focused on specific issues, that clear context for the specific ToR is provided, and that presentations are clearly focused on helping reviewers attend to those ToR. More thought needs to be given to allowing for in-depth discussion and real-time analysis rather than broad brush review of multiple topics and over-emphasis on presentation.

REVIEWER'S ROLE IN THE REVIEW ACTIVITIES

The role of the reviewer is set out in the CIE Statement of Work, Attachment A, attached here in Appendix 2, Attachment A. All three CIE reviewers are tasked with producing an independent report. The reviewers were not tasked with producing, or contributing to, a group report.

SUMMARY OF FINDINGS

ToR a *Evaluation, findings, and recommendations on quality of input data and methods used to process them for inclusion in the assessment (specifically fishery and survey data).*

Observers

The Alaskan observer coverage is the envy of many fisheries regimes worldwide. For Alaska as a whole (not just EBS pollock), catcher processors and Motherships have 200% observer coverage. Jointly, these highly observed vessels contribute *circa* 60% of the total catch. Catcher vessels over 125 ft have 100% coverage and each vessel over 60 ft (but less than 125 ft) has 30% of its fishing days observed. Vessels less than 60 ft are not observed. In total, approximately 70% of catcher vessels are observed. For EBS pollock, approximately 70-80% of the catch has been subject to direct observation.With impending salmon bycatch management arrangements, coverage of all vessels will be expanded to at least 100%. This increased coverage, in addition to increasing the overall EBS pollock catch observed to nearer 100%, will potentially overcome a potential shortcoming in the current design caused by the 30% coverage of smaller vessels being non-random and at the discretion of the vessel.

At-sea delivery is by five independent provider companies paid directly by fishery operators, but the Observer Service, responsible for design, analysis and quality assurance is federally funded. Coverage is good, designs are sound, constantly reviewed and, where necessary, changed. At-sea observers collect samples from fish and incidentally caught species but also serve a compliance role. In principle, this dual scientific observer and compliance reporting role could cause conflicts but there has been no suggestion of problems in this area.

The scientific observer program is the fundamental data acquisition program for all biological and fishery data that feed in to stock assessment and management. It is essential that the service is maintained at the high standard already achieved and it is heartening to see so much effort in the area. Of particular note is that the fishing industry also values the high quality information provided by the observer program and has waived confidentiality agreements as to data use in order collectively to work to improve fishery performance, especially in relation to reducing the incidental take of species other than pollock. To this end, the The Pollock Conservation Program (PCC) contracts with a private sector firm, Sea State, Inc., to monitor incidental catch. Sea State is authorised by the individual catcher/processor companies to “download proprietary catch data submitted to NOAA Fisheries on a real time basis. Sea State reviews this data and advises vessel operators of bycatch “hotspots" to avoid. Harvest cooperative members cease fishing in an area if bycatch is encountered and move to other fishing grounds.”
(http://www.atsea.org/fishing_coops.php)

Trawl and acoustic surveys

In addition to the fishery information provided through the observer program, the key stock assessment inputs for EBS pollock are derived from the bottom trawl survey (BTS) and the echo-integration trawl (EIT) survey. Work is also being carried out to extend the use of opportunistic acoustic data (OAD) information to study population responses to environmental changes and to using acoustic data collected from the BTS which might be used to "fill in" EIT information in years where the EIT does not operate. During the review, excellent presentations were given and ancillary information provided on all of these topics. It is frustrating that insufficient time was available properly to attend to the many issues raised. The surveys could usefully have been the subject of a single review but were in fact all presented in a single afternoon with insufficient time for discussion. The overwhelming impression was of excellent work and careful thinking as to use for stock assessments, input to the Bering Sea Integrated Ecosystem Research Program (BSIERP), and constant improvements and future developments.

The BTS is a general purpose, low headline, trawl survey aimed at providing information on a wide range of species. The BTS has been running since 1975 but with changed (standardised) trawl gear in 1982 has effectively run since that time. In 1987 new stations were added to the survey and from 1988 to present can be viewed as a continuous series. The survey is conducted using standardised gear and design on commercial vessels. The same two commercial vessels have been used continuously since 1994 and great care is used to standardise the results. The number of stations and survey duration has been fairly constant in that time although the survey timing has varied somewhat. The survey covers a 20 X 20 nm grid laid out over 12 zones spanning the whole EBS area. The only optimisation is for blue king crab for which additional stations are fished. There are no special measures or adjustments for pollock. However, consideration of pollock biological sampling has led to changes since 2006 in the way otoliths have been collected. Previously, otolith sampling was concentrated on low density pollock areas (not by design). This has now been attended to and it is hoped that age compositions will better reflect pollock distribution and density patterns; this will need to be tested. Other recent changes include a pre-emptive extension to the north in expectation of pollock distributional expansion with warming (climate change). It is unclear how this expansion will be designed and how biomass estimates will be modified.

The BTS provides important information on annual pollock spatial distribution, on recruitment (as age 1) and on total biomass, as well as age composition data. The BTS is especially efficient at selecting 1 year old pollock (selectivity appears to be about 50%) but not 2 and 3 year olds which are distributed higher in the water column. The BTS is conducted using commercial vessels equipped with Simrad ES60s. Work is in progress to integrate backscatter within the headrope height (and above the acoustic dead zone) to produce pollock cpue estimates that can be combined with the trawl estimates to provide a single estimate. If successful, this approach should lead to BTS derived biomass estimates with overall lower *cv*s.

In the review, there was a lack of clarity as to how the integration of ES60 information within the headline height of 2 m was possible, given that the acoustic dead zone was likely of the order of 1-2 m (given the depths and topography of the surveyed area). Echo integration for the EIT is from 3 m. The EIT uses Simrad EK60 equipment which is effectively the same as the ES60 used in the BTS. It is unclear why the EIT is integrated only from 3 m, especially as the ES60 backscatter from the BTS is being explored at less than 2 m from the bottom.

The EIT is a dedicated pollock survey, independent of the BTS. It has been operating since 1979, initially triennially, then biennially and since 2006 annually due to additional effort associated with the BSIERP and Loss of Sea Ice Program (LOSI). The annual work will stop from this year and is one motivator for continued work on BTS acoustic "filling in" (and perhaps also OAD explorations of biomass estimation). Pollock are an ideal acoustic subject, having strong backscatter and forming large, reasonably unmixed schools. The methods to estimate numbers and biomass are relatively straightforward, working up echo integration data to estimated numbers *via* application of length frequency data and target strength at length relationships to develop appropriate mean acoustic cross sections. Appropriate biological sampling using a variety of mid water nets to permit numbers estimation is undertaken during EIT cruises. There seem to be few issues with the EIT approach. However, there are a number of "challenges" recognised by the AFSC EIT team and these are being explored.

The majority of the challenges noted are general to the EIT method for all fisheries and it is good to see progress being made on these; this should be encouraged and continued. Many of the work areas are also being attended to in other areas and it is clear from discussions that AFSC staff members are well aware of this and are well positioned to participate and/or lead such work. The two EBS pollock specific challenges raised by the AFSC staff relate to the survey area definition and to the appropriate water column height for echo integration.

The first issue relates to EIT coverage relative to the stock distribution. This issue decomposes in to two issues: 1) overall survey coverage and 2) within area coverage. With respect to total area coverage, the survey does not extend beyond the shelf and has only in recent years expanded to cover the Russian zone. There appears to be little problem with (1) and it is good to see recent northward expansion in to the Russian zone. With respect to (2), the EIT transects are not fixed, like the BTS, but have endpoints responsive to pollock detection. The annual EIT transect coverage is therefore generally less than the more expansive BTS. This is not necessarily a problem, especially if the EIT biomass estimate is used as a relative index and so long as transect endpoint criteria are consistent across surveys. Transects within the main EBS area have 20 nm spacing; although transects are long, it is therefore unlikely that fish movement could lead to double counting between transects. (For the Bogoslof area, with 3 nm spacing, this might be a factor to consider in EIT design.) Overall, the EIT design and ongoing research seems appropriate.

The one outstanding issue is the use of the 3 m cut off for echo integration. It is unclear why this is the case. Given the relatively shallow and smooth bottom, the dead zone is likely of the order of 1 m or less across most of the pollock depths, though possibly greater in some of the deeper strata. Given that the BTS does not do a good job of selecting 2 and 3 year olds it would be especially useful to explore the potential for EIT integration to shallower depths (if appropriate size sampling is possible to allow estimates to be worked up). It is notable that the BTS uses sampling gear up to 2 m off the bottom while the EIT sampling gear does not apparently cover depths deeper than 3 m from the bottom. Within the BTS program attempts are being made to integrate ES60-derived backscatter from within the 2 m from bottom range and for the EIT only backscatter shallower than 3 m is being integrated. It appears that there is scope for improvement in overall backscatter integration. From the review it was unclear how this might be approached but it is **recommended** that a clear strategy for progress should be laid out.

It is especially important to make as full use as possible of acoustic information during a time of relative biomass decline and when the EIT will again move to a biennial pattern. A clear way forward to using commercial vessel captured (ES60) acoustic information would also be timely given OAD work to use extensive commercially captured acoustic information to study pollock population responses to environmental factors but also potentially to estimating biomass. The impressive OAD work is well advanced and clearly holds much promise within the ecosystem management context but the initial ("*very preliminary*") results on biomass estimates for 2002-2005 do not look promising (see slide 47 of CIE_CoopRES_Barbeaux).

ToR b *Evaluation, findings, and recommendations on the level and adequacy of knowledge on pollock stock structure, biology, and life history.*

Stock Structure

Genetic analyses (as presented in *Canino_2010*) clearly reveal that while there may be genetic pattern variation between spatial groups of pollock, these variations are not stable in space and time and exist only on a wide scale (not local). This is not surprising given the speed of population level responses to environmental change. Nor is it surprising given the wide and continuous pelagic distribution of pollock.

The text figure below shows a map copied from a presentation given during the review (*Assmnt_1_CIE*). The map usefully summarises non-genetic information relevant to choice of stock units for assessment and management. It is clear that EBS pollock do move beyond the current EBS stock boundary, at least in to the Bogoslof area and likely beyond. Given that Bogoslof has been closed since 1991, then assessment and management at the EBS scale should in principle be conservative. Given also 1) data are organised for assessment at the EBS scale and 2) allocation is at the EBS scale, it would appear sensible and appropriate to continue assessment and management at this scale. Only if clear information (most likely through high resolution genomics) suggested otherwise, would it be worthwhile reconsidering stock assumptions. If that were the case, given the difficulties of redefining assessment and management areas, it would be sensible rather than changing management units to consider the management consequences of stock misspecification through management strategy evaluation.

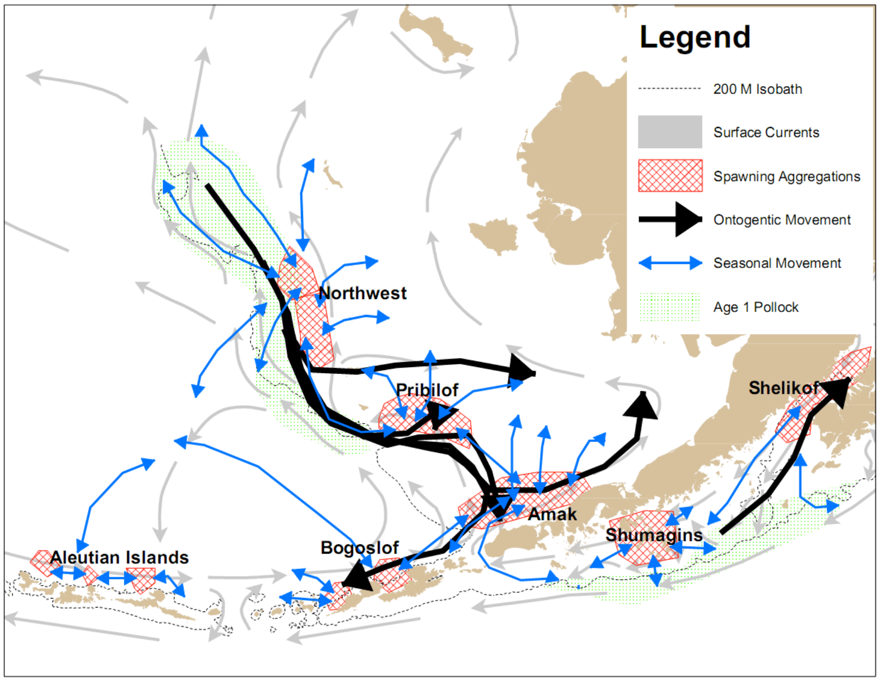


Figure copied from Ianelli presentation (Assmnt_1_CIE, slide 7)

Natural mortality

The natural mortality of pollock has been the subject of an extensive National Stock Assessment Workshop held during 2009 at AFSC. Based on the combination of the now relatively standard Lorenzen form for natural mortality at age and a logistic model for older fish scaled to maturation, that workshop developed a vector with a similar form to that used in recent assessments (high age 1 mortality, declining with age) but with generally higher values of natural mortality for ages 3 through 15 (2009 SAFE Report).

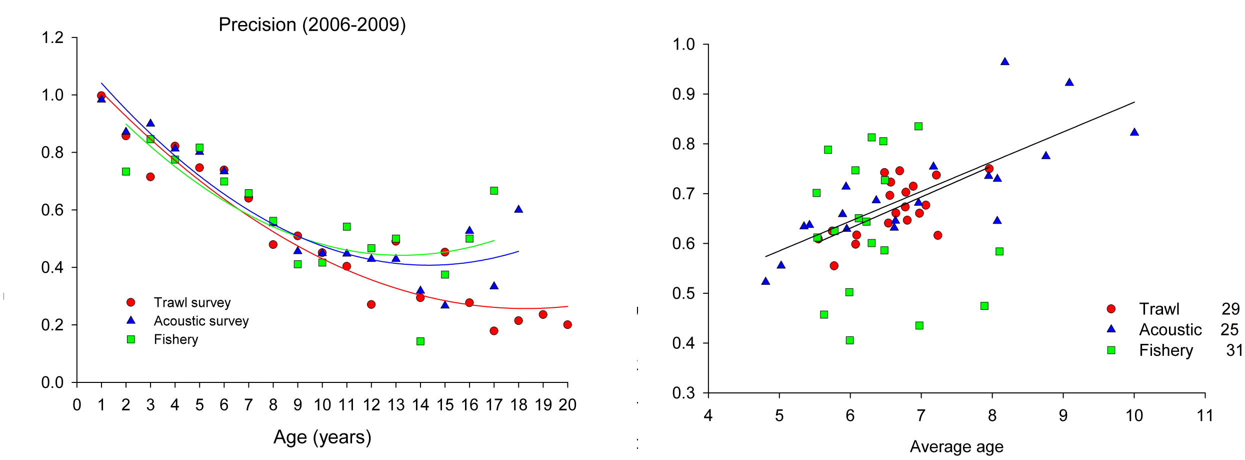
MSY-related reference point estimates as used in Tier 1 harvest control rules are potentially sensitive to the values of natural mortality used in the stock assessment. The vector of natural mortalities used in recent and the current stock assessment assumes a constant value of 0.3 for ages 3 and older, 0.45 at age 2 and 0.9 at age 1. These values for young ages are lower than suggested by the recent workshop or from multispecies assessments, and therefore appear conservative with respect to F_{MSY} estimation (because F_{MSY} correlates positively with natural mortality for any given partial exploitation pattern).

The 2009 Greenpeace stock assessment review notes that things are more complicated than this because of the additional effect that would be caused by increased natural mortality on young ages leading to increased estimates of recruitment and hence potential impacts on estimates of steepness, which also affects F_{MSY}. I am not convinced by this - a time-invariant increase in the natural mortality vector will increase recruitment but this should re-scale recruitment across all years with little if any impact on steepness estimation. It is, however, these complexities that suggest the need for thorough sensitivity testing as to how the choice of natural mortality affects management outcomes (see ToR c, below).

Age reading

The EBS pollock assessment uses a statistical catch at age model which fits a (very) large number of parameters to define annual, age-specific selectivities for each component (fishery, trawl survey, echo integration survey), each with its own catchability parameter. Although a statistical model allowing for age composition errors, the high parameterisation effectively allows the age data to be fit very closely and the age compositions are highly influential in the model fit and subsequent advice. It is important to ensure that the best possible age reading is available but also to ensure that errors in ageing are appropriately captured in the quantities of interest to management, especially in the Tier 1 regime where a reliable *pdf* of F_{MSY} is required, ideally through appropriate use of an age transition matrix in the model fitting.

The otolith collection by observers in the fishery, and from trawl and echo integration surveys, is high and there is clearly sufficient thought given as to sampling intensity. During the review, however, concerns were raised by the age reading methods employed and by the apparent low level of agreement between readers. With regard to method, otoliths are read using any of three methods (surface reading, break and burn, and baking). The method used for any otolith is "*left to the discretion of the Reader ageing the sample*" (*EBSpoll_Age-Growth_CIE2010, slide 5*).



Figures copied from EBSpoll_Age-Growth_CIE2010, slides 9 and 10.

The precision as measured by percentage agreement between readers is poor by *gadoid* standards, dropping quickly with age and also varying by component (fishery, trawl survey or echo integration survey; see figures). As explained during the review, readers have discretion as to methods used and training consists of comparison with a standard reader with the period "*varied dependent on agreement*". Over the past 20 years, 17 readers have been used for EBS pollock, with individual readers having read anything from a "*few hundred to close to 7,000*" otoliths. It was not possible during the review to break out statistics to explore how methods used may have varied through time or by component, or how reader agreement may have varied.

It is not clear that the assessment properly considers ageing error and feeds this uncertainty through to final MSY-related estimates and ABCs. In this respect it is **recommended** that the ageing procedures and consistency statistics be reconsidered and that consideration be given as to whether or not a new age transition matrix should be developed and used at least for assessment sensitivity testing (see ToR C, below). It is also **recommended** that the ageing protocols should be reviewed with a view, if necessary, to tightening them up to achieve greater consistency.

ToR c *Evaluation, findings, and recommendations of the analytical approach (application of a statistical ADMB integrated catch-age model) used to assess stock status and estimation/presentation of uncertainty including MSE approaches.*

Insufficient time was available during the review fully to investigate the fit and behaviour of the assessment model. No attempt was made to delve in to the details of the model structure or to validate it. However, the report on behalf of Greenpeace, for which full code was provided, made a good start at validating code and understanding model behaviour. Based on that report, there seems no reason to doubt model coding and the general approach.

One point that has been repeatedly made, including in the Greenpeace review, is that the model is over-parameterised. In effect, though formulated as a standard statistical catch at age model with multiple indices, the model is a separable VPA, fitting age and year selectivity components for each catch at age cell. Prior to 2009, the assessment was similarly structured but only fit selectivities biennially. The increase in parameters from 2008 to 2009 is due to the change to annual selectivity fitting. While increasing parameters, the structure is potentially more revealing and is easier to interpret. The key issue is not so much one of over-parameterisation, as are uncertainties appropriately accounted for and carried through to reference point calculation and forecasts.

All assessments link data and management action, though provision of necessary indicators and forecasts. Given a stable harvest strategy framework (the NPFMC Tier system), and given stable data flows (catch at age, BTS, EIT etc), it is appropriate also, for consistency and stability of management, also to use a consistent assessment approach. Of course, from time to time, in response to data flows or external information, it may be necessary to change the assessment configuration. To the extent possible, however, consistency should be the order of the day. The EBS pollock assessment has been reasonably consistent for a decade or more but some changes are still being made. The parameterisation of selectivities is one example, but the steepness prior used in 2009 is also changed and so too are effective weightings between catch at age, EIT and BTS. Care needs to be taken when such changes are made to ensure consistency of advice. Standard approaches to this include making “continuity runs”, sensitivity testing, retrospective analyses and quality controls analyses, etc. Of course, as in any model fitting exercise, care also needs to be taken to explore general model diagnostics.

As reported in the SAFE Report and as presented for review (Assmnt_1_CIE) some of these elements are missing. No continuity run was presented to compare how changing from biennial to annual selectivities might affect management advice, no sensitivity tests or retrospective analyses were shown for key indicators (e.g F_{MSY}), no specific new sensitivity tests were shown (although many have been considered from 1998 to 2008, as shown in the presentation, slide 44) except to new data sources (“CABE”). No diagnostics (e.g. residual plots) were shown. Only during the review meeting was any detailed assessment output provided (in the form of a spreadsheet of F and exploitation rate results). Given the lack of such materials, and very limited review time, this made both review of the assessment *per se*, and of the assessment within the harvest strategy/management framework, difficult. It is **recommended** that where a stock assessment is to be reviewed, the ToR should focus on that activity and that more time and more detailed information be available. Information should include clear model outputs and diagnostics (e.g. residuals, MCMC traces and comparisons); distributions of final year F, FMSY and other management quantities of interest; full sensitivity testing to major structural assumptions, key parameters, etc; impacts of new data (e.g., CABE); continuity assessment; perhaps a breakdown of factors contributing to the forecasts; etc. Note that this is not a criticism of what was presented but rather reflects on the too wide ToR limiting what could be achieved with respect o review of the assessment.

Despite these comments, a number of issues of note emerged during discussion.

The assessment is structured as a Bayesian assessment but is not fully integrated. Rather, it only approximates the posterior distributions of quantities of interest. This has been previously explored and it has been found that the approximations are close to the fully integrated estimates. However, with changed structure (annual selectivity estimation), changed assumption of the steepness prior (critical in defining F_{MSY}), and with B approaching a trigger point ($B_{20\%}$), it would seem wise to check again that the approximation is robust. During discussion it was noted that full integration is highly time consuming and that an approach to smoothing the annual selectivities using splines (therefore reducing parameters) was being investigated. This may be a useful step. Generally, even if the approximation is “poor”, it would still be possible to use the approximate methods – but this would need to be tested using MSE.

Given the harvest strategy and HCR definition (see ToR (d)) where F_{ABC} is reduced from F_{OFL} by choosing the harmonic mean of the *pdf* of F_{MSY}, it is important to allow appropriate errors to flow through the analysis. The harvest strategy is not formally tested (by MSE) and is intentionally precautionary (arguably low steepness prior, low M, stock definition); nevertheless, given the formulation, it is important that all error is fully integrated. A key issue in this respect may be the ageing error alluded to under ToR(b). Ageing error was last considered in 2006 but the age transition matrix shown during the review did not appear fully to capture the extent of ageing error that might exist. Allowing for greater "leakage" across ages would potentially change both recruitment estimates and selectivity at age estimates through time. It is **recommended** that further consideration be given both to better defining the age transition matrix and to exploring management implications of increased ageing error.

Forecasts depend both on estimated stock structure and future recruitment, and on assumed selectivity. The assessment estimates selectivity at age in every year and the forecast selectivity is the average of the four most recent estimated selectivity vectors (SAFE Report p 68 and appendix). Selectivity is only allowed to vary slowly, with the freedom to vary constrained by a single parameter (SAFE Report appendix, eqn 3). Even though constrained, there is considerable annual variability in selectivity (SAFE Report Fig 1.26) and forecasts will likely be sensitive both to the averaging employed, the value of the constraint used and the way in which errors are propagated. It is particularly worrying at a time when a) biomass is approaching a trigger point, b) new salmon bycatch measurements are due to be implemented, c) selectivity seems to be shifting to younger fish following recent multi-year poor recruitment, that the forecast selectivity could be quite wrong. It was not possible in review to go further with this point but it is **recommended** that consideration be given to the sensitivity of selectivity and hence to forecasting and ABC estimation.

Spawning exploitation rate (SER; see e.g. SAFE Report Fig 1.39) is estimated to have been decreasing sharply since 2007. Exploitation rate as a fraction of F_{MSY} has been fairly stable for a number of years, though increasing in 2009, even as biomass as a fraction of B_{MSY} has declined (SAFE Report 1.35). For 30 years, apparently fishing mortality rates have been of the order of 0.3 to 0.5 F_{MSY}. A number of issues arise from these plots. First, despite F being so low with respect o F_{MSY}, for so long, spawning biomass has declined quickly to below B_{MSY}. Clearly, the decline is in response to a period of poor recruitment, but the pattern does raise a question as to the appropriateness of the harvest strategy or of the assessment/forecast to inform it. Second, why is SER declining sharply (a positive sign), while F is increasing and biomass decreasing? The answer lies in the SER definition which includes the current SPR given estimated current selectivity. As selectivity has shifted to younger fish, in response to poor recruitment, SER has declined even though F for all ages has increased – it's just that even the increased F for the now selected younger ages is less than the earlier F on older ages. There is nothing wrong with this, but there is a need for great care in presentation so as not to give misleading messages.

There is no right or wrong way to present information on exploitation rates. The best presentation will depend on the harvest strategy in place and agreed management indicators, but also needs to "speak" to a wider audience in a way that is transparent and not potentially interpretable as misleading. It is **recommended** that some thought be given to whether or not alternative ways of representing changes in exploitation rate might be useful.

ToR d *Evaluation, findings, and recommendations on the appropriateness of the harvest strategy used by the North Pacific Fishery Management Council (including uncertainty adjustments).*

This ToR is extremely wide in scope, potentially including considerations well beyond those associated solely with EBS pollock and extending to consideration of the whole North Pacific FMC Tier system, other TAC-setting consideration, the groundfish cap, and monitoring and assessment. It is also unclear in the ToR what is meant by "appropriateness". The simplest way to interpret this is in the context of the relevant legislation and management system. To that end, this ToR (d) and ToR (e) have already been considered in detail by a review prepared for the NPFMC in late 2002. The report of that review, and a response by the AFSC, were included in the background documentation.

Relevant information presented during this review included a presentation by Council staff on general EBS pollock management and a presentation that explored the current control rule for setting ABCs (a formal and central component of the harvest strategy) in the context of potential environmental change and the appropriateness of maintaining or changing the control rule in use.

In general terms, the EBS pollock harvest strategy is a single-species MSY approach using a defined harvest control rule (HCR) to determine the OFL and ABC at given estimated stock biomass. The ABC is less than the OFL to reflect uncertainty in estimation. Both the OFL and ABC are technical outputs from formal stock assessment processes and follow from the designation of EBS pollock as a Tier 1 stock. The TAC cannot exceed the ABC and will generally be set lower to reflect a variety of concerns/issues. The strategy for setting the TAC includes less well defined considerations in response to real and/or perceived social, economic and ecological concerns. Prominent current concerns are the bycatch of salmon and the possibility of reducing forage for Steller sea lions. These external concerns can lead to modifications from within the MSFCMA or other legislation, notably the Endangered Species Act (ESA) or the Marine Mammal Protection Act (MMPA). These issues are returned to at ToR (e).

The HCR for EBS pollock is shown in the text figure below (copied from presentation HarvestStrat). The Figure shows the EBS pollock HCR but superimposes an over-ride due to the ESA and provisions to protect forage for Steller sea lions. The dashed line, labelled "F-realized", shows that the effective exploitation rate is reduced as biomass increases because of the imposition of an overall EBS groundfish cap of 2 million tonnes.

As a Tier 1 stock, the F_{OFL} for EBS pollock, is the point estimate of F_{MSY} (i.e., the "best" estimate without adjusting for uncertainty), and the target F_{ABC} is the harmonic mean of the *pdf* for F_{MSY}. The harmonic mean is less than the arithmetic mean by an amount that increases with the spread of the *pdf*, thus creating a margin that increases with the uncertainty in the estimate of F_{MSY}. In general the distance between the F_{ABC} and F_{OFL} may be small and may not fully reflect uncertainties or natural variation in the quantities – judgment as to whether or not this is the case for EBS pollock necessitates a careful examination of the assessment and its outputs, especially the *pdf* for F_{MSY}. However, the *pdf* for F_{MSY}, though critical in ABS determination, nor explicit characterisation of how it is sensitive to assessment assumptions, is not contained in the SAFE Report and was not presented in review. This is a shortcoming and it is **recommended** that future SAFE Reports contain this information as a matter of course, together with a comparison of the *pdf* with that from the previous assessment.

A harvest strategy is more than a HCR. At a minimum, it needs to be viewed as the combination of monitoring requirements, the specification of the assessment, and the HCR. It is the inter-play between these elements that underpins strategy expectations and performance. The quantities of interest in the HCR are outputs from the assessment and the uncertainties expressed are features of the assessment. Ideally, to maintain a consistency of meaning and interpretation through time, the assessment would be consistently conducted, updating solely in response to new data. There is, however, no requirement for this in the NPFMC system and it (the assessment) may in fact be varied annually, not just as new data are added but also, for example, through changing assumptions, modelled structure, and minimisation routine. The EBS pollock assessment has been stable for some years but in 2009 was changed in a variety of aspects (e.g., increased parameterisation to estimate annual selectivity patterns, changed effective weightings, changed prior for "steepness"). These changes inevitably change, perhaps subtly, the way in which the model interprets data, and especially should affect both MSY-related estimates and estimates of associated uncertainty. Given the changes to the EBS pollock assessment in 2009, it would be normal to see a "continuity run" using the previous model, sensitivity testing relating to the changed assessment aspects, and clear diagnostic outputs at least of the *pdf*s of quantities of interest, notably F_{MSY}.

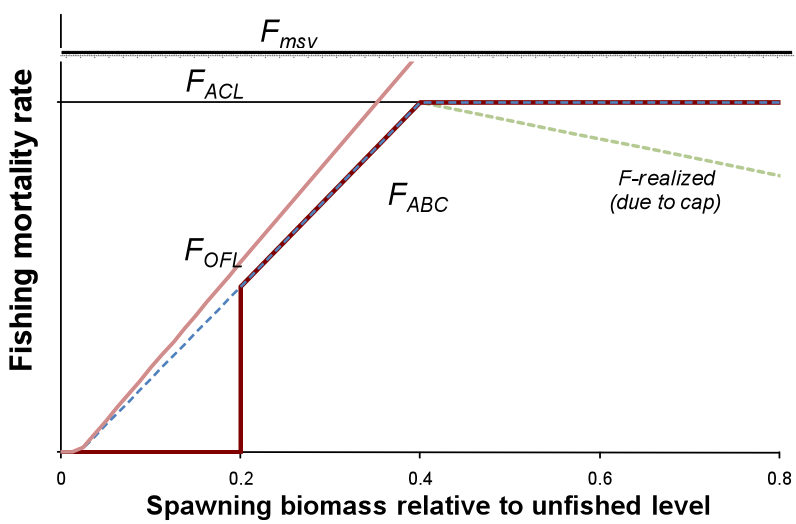


Figure copied from HarvestStrat, slide 8

General issues of sensitivity are covered in the section above on stock assessment (ToR (c)). One key parameter that affects advice in the Tier 1 system is the assumed value, or prior, for steepness. The 2009 assessment used a higher centred and tighter prior for steepness than used previously and this should in general reduce B_{MSY} as a percentage of B_0. However, even the prior used appears somewhat conservative given general knowledge about appropriate priors. In this sense, the assessment and implementation of the Tier 1 strategy appear intrinsically conservative, regardless of changes from previous years practice. Regardless of technical matters, in practice, as TACs are generally set consistent with exploitation rates well below F_{ABC}, **no concerns are apparent with the current ABC advice**.

The HCR for EBS pollock is defined by the general Tier framework adopted by the NPFMC. From a strictly fisheries perspective as applied to meeting MSFMCA requirements, the Tier 1 HCR is a rational rule, which if applied with consistent assessment, should lead to good fishery behaviour – the stock maintained at a high level and with few or no closures. However, at least two issues need to be considered. First, the superimposition of the ESA provisions that create a breakpoint at $B_{20\%}$ might best be described as “ugly”. The simple MSE work described below clearly demonstrates that the HCR including the $B_{20\%}$ provision can lead, under low recruitment, to fishery closures. It would be sensible to consider alternative HCR that would mitigate this feature. Second, and linked to the first issue, is that if the $B_{20\%}$ provision is invoked then the data necessary for assessment, forecasting and provision of Tier 1 information will be affected. It is possible therefore that advice for pollock ABC could revert to a lesser Tier, with slightly different HCR. Certainly, at a minimum, information on recruiting year classes will be attenuated, causing loss of forecasting power. Similarly, loss of information on selection pattern will impact forecasting. A full MSE would therefore require very complex MSE would consideration of how the HCR affects information flow, affects assessment and forecasting, affects Tier usage, etc.

Simple management strategy evaluations (MSE) presented during the review provide some insight as to possible future stock development if the current HCR were applied to guide TAC-setting in the case of changing climate and reducing pollock productivity – and assuming consistent application of the current assessment configuration and Tier 1 application. Given the relationship used to relate recruitment to sea-surface temperature (SST) it appears that if the current HCR is applied rigorously, and if TACs/catches conform to the resulting ABCs, that mean SSB would be expected to decline very slowly, but that mean catch would reduce faster and, importantly, with greater frequency of fishery closure due to sea lion provisions being triggered. The thrust of the presentation was that fishery managers will face tough choices and need to be adaptive.

The work of course relies on a given recruitment-SST relationship and the predictive power of the such is notoriously fraught. However, the modelling sensibly combines the relationship with an ensemble of climate change scenarios to develop a useful, general picture of potential future productivity changes. The MSE considers a range of modified HCR and uses a simple utility approach with a constrained set of indicators to reveal how alternative HCR might differentially perform with or without climate change. The bottom line is that with no climate change, the current HCR performs about as well as the alternatives considered but that in the face of climate change, given the defined utility function, there is considerable scope to improve management performance by adjustment of the HCR. It is interesting in this respect that depending on the utility function (i.e., weighting of chosen indicators), the choice of alternative HCR would vary. As ever in fisheries management, this highlights the need for clarity and explicit consideration of objectives.

Taking a wide view of the MSE work, it is an interesting examination of how the EBS pollock could react to climate change and provides some insight in to how harvest strategies, formally implemented through the well defined HCR or informally in TAC setting, may need to adapt. A particular choice made clear by the MSE work is that if the scenarios investigated where to eventuate, and if the $B_{20\%}$ over-ride were maintained, an even more conservative single species strategy might be required to mitigate the risk of fishery closures. Returning to the point made above about the "ugly" HCR, the MSE work could also provide a basis for modification of the existing HCR to achieve better fishery performance.

In general response to the ToR, and in line with general comments made in the 2002 review, the NPFMC single species harvest strategy as applied to EBS pollock is a conservative one, with the default target biomass set at a level at or above a likely true B_{MSY} level (given life history characteristics and reasonable assumptions as to recruitment dynamics), with the ABC adjusted downward from the OFL to reflect uncertainty in estimation, and with further downward adjustments in TAC driven by less well-defined factors. Considering the wider modifications able to be implemented for bycatch reduction etc, and monitoring and assessment provisions, the harvest strategy appears currently to be sound. Consideration of long-term changes (reduction) in productivity could lead to the need for reconsideration but overall, it is **recommended** that the EBS pollock single species harvest strategy, using Tier 1 rules, is currently "appropriate" given legislative requirements and the management system in place. If, however, the bycatch provision over-ride is invoked, and if therefore information available to the assessment changes, it may not be a simple matter of just continuing with the strategy as the fishery is re-opened. It is **recommended** that the MSE work be extended, including consideration of data flows and Tier usage, to examine in more detail how the $B_{20\%}$ over-ride provision potentially impacts on the general pollock harvest strategy. Including full specification of data flows, assessment changes and criteria for switching between Tiers would be difficult but use of additional indicators to reflect the reliability of the *pdf* on F_{MSY} and forecasting power could be developed to provide an indication of strategy sustainability.

ToR e *Evaluation, findings, and recommendations of whether harvest strategy is adequate within an ecosystem approach to management (e.g., bycatch, importance of pollock as forage).*

As for ToR (e), this very wide ToR was little attended to during the review. Only one specific (and very interesting) presentation was made on ecosystem modelling and assessments in Alaska

(CIE_Aydin) and there was little time for discussion on the topic. It is unclear what "harvest strategy" is referred to in the ToR. Indeed, given the lack of article in the ToR it is unclear if the reference is to the EBS pollock harvest strategy (or even HCR) or a more generalised Alaskan harvest strategy. Similarly, what is meant by "adequate" depends on the objectives and specific utilities within any ecosystem approach. Given the difficulty of interpreting the ToR, and the fact that the NPFMC 2002 review addressed the ToR in more detail, only general comments are made here. However, two specific issues are addressed: salmon bycatch and provision of sea lion forage.

From the presentation made, the AFSC is clearly well advanced in terms not just of ecosystem monitoring and modelling, but also in reporting for potential management consideration. While no specific ecosystem indicators with direct relationships to management actions yet exist (i.e., no ecosystem HCRs), there is a clear flow of relevant information from the AFSC, through the Plan Team to the SSC. As reported through the presentation, the SSC has taken wider ecosystem information on board in formulating TAC advice. In the sense that the harvest strategy for EBS pollock includes the setting of TACs less than the ABC and as informed on a variety of issues, including ecosystem matters, then the harvest strategy is apparently at least considerate of ecosystem needs.

Of note in the Alaska region is the high degree of fishery monitoring, real-time reporting and use of information both for regulatory and collective, voluntary measures. Overall, the system, underpinned by world class research, is arguably the best placed and most advanced implementation ecosystem management, or management considerate of ecosystem needs, in the world. With major programs and work already underway to synthesise multispecies and ecosystem advice as a matter of routine, especially the BSIERP (including MSE as recommended by the 2002 review) and FEAST, it is likely that the AFSC will be able to provide relevant and credible scientific advice to help the SSC formulate single species TAC advice which is adequately cognisant of ecosystem needs.

In the meantime, practical strategies to address wider ecosystem issues or other specific issues seem to be the way forward. The salmon bycatch and sea lion provisions fall in to this category. Neither is a real ecosystem management response but both can be viewed as a wider ecosystem consideration to be taken account of when managing EBS pollock.

Salmon (Chinook and Chum) bycatch has previously been managed in the EBS pollock fishery based on a voluntary "rolling hotspots" approach coupled with regulated real-time closures. Real-time observer information has been used for the purpose, as run by Sea State Inc (see ToR (a)). Despite this, bycatch has been high in recent years (though apparently not in 2010) and the need to find an alternative approach has been highlighted. The problem derives not just from the need to prevent salmon overfishing *per se*, or for any specific ecosystem need, but also in order to meet National Standard 8 under the MSFMCA – to provide for the sustained participation and minimise adverse impacts on fishing communities. From 2011, under NPFMC Amendment 91, as well as specific closures, a hardcap for Chinook bycatch will be put in place, split on the A and B Seasons and with potential for pollock fishing to be halted in either season as the hardcap is approached. Measures for Chum have yet to be agreed but could include a hardcap (for the B Season only) or area closures which are more readily identifiable than for Chinook and may be more viable.

How the Chinook hardcap was set by Council was not discussed in detail during the review. Neither, in detail, was the added Incentive Plan Agreement (IPA). The important message taken from the review presentation (CIE_Salmon_bycatch) is that the management arrangements adopted will be adaptive, combining regulated and voluntary components, that there is good use of scientific information to underpin management decisions, and provision for necessary future monitoring. The drivers for salmon bycatch reduction are clearly related to the importance of salmon to Western Alaska communities which have a high dependence on salmon and progress has been made presumably also because of the strong position of CDQ groups which have interests in major pollock fishing companies. Regardless of drivers and political context, the Chinook management plans appear robust both technically and operationally, with a careful blend of regulatory measures and standards and voluntarily implemented bycatch reduction methods and incentives plans (SSIP, Salmon Savings Incentive Plan).

Taken as a whole, the measures to conserve salmon, primarily to meet community needs, constitute an additional potential constraint on pollock fishing and will lead to improved overall monitoring and fishery practice. The arrangements demonstrate the willingness of Council to take measures beyond already conservative single species harvest strategies to attend to the wide set of objectives laid out in the MSFMCA.

No dedicated presentations were made during the review on the ESA provisions for Steller sea lions. However, a letter from Oceana (attached in appendix 3), sent to the NPFMC Chair and NMFS Regional Director on December 7th 2009, was circulated. During the review, John Warrenchuk of Oceana was asked to speak to the letter and some discussion ensued. Additionally, discussion on the provisions took place during consideration of the HCR under ToR (d), and when considering the MSE work considering potential climate change.

The concerns of Oceana relate to the potential near-term decline in pollock biomass to below $B_{20\%}$ and whether or not sufficient account is taken of in-season, not just start of year, biomass availability to sea lions. Oceana is also concerned at the assessment accuracy, and retrospective reductions in biomass estimates; the current high mortality on older fish, and on a perceived shifting baseline, due to the way B_0 is calculated.

The Oceana concerns prompted discussion on the basis for the $B_{20\%}$ provision. It proved surprisingly difficult to trace the basis for the provision but the decision seems to derive from an analysis by De Master in 2000. The reference for the paper, which is clearly an appendix to a larger document, is unclear. Therefore, for completeness, a scan of the paper as circulated during the review is attached at Appendix 3. The paper takes a simple approach to defining an EBS pollock biomass sufficient to provide for a Steller sea lion population at its carrying capacity.

Many conservative assumptions are made which lead to the suggested $B_{20\%}$ level. It appears that the suggested level is a simple and conservative provision that would be sufficient in the face of considerable assessment uncertainty and regardless of in-season biomass variations, even if the Steller sea lion population where at carrying capacity. Given that the sea lion population is currently only of the order of a quarter of its carrying capacity, the provision is currently highly conservative. Given that a new Biological Opinion is currently being developed, it would seem prudent to wait on that opinion. In the meantime, despite concern about EBS pollock biomass status, there would not seem to be need for urgent or special action (*http://www.fakr.noaa.gov/protectedresources/stellers/esa/biop/status.htm*). However, as noted at ToR (d), use of the $B_{20\%}$ provision could potentially have a major impact on pollock management as it could "unsettle" the harvest strategy more than seems to have been contemplated.

The Oceana concerns about the assessment and forecast accuracy are touched on in ToR (c). Two issues are of note. First, that exploitation rate on the "prime ages" of pollock is at a 31 year high. Second, the issue of "shifting baselines".

The Oceana letter correctly points out that the exploitation rates are at an all time high. This issue relates to how exploitation rate is portrayed (ToR (c)). The reported trends in spawning exploitation rate, as seen in the SAFE Report, figure 1.33, are correct. However, as revealed only by careful scrutiny of the individual mortalities at age, through time, this masks the picture of overall increasing exploitation rate at every age. The discrepancy comes about because of the way the spawning exploitation rate is calculated, accounting for changes in selectivity. Recent overall spawning exploitation rate has declined because of the change in selectivity to favour younger ages. Although the exploitation rates on those younger ages have also increased, they are still less than the previous rates on older ages. At a minimum, it is **recommended** that alternative means of portraying spawning potential are explored, and of displaying exploitation rates. The current means, as used in SAFE, Fig 1.33, is misleading. As pointed out by Oceana, it is possible that the size structure of the spawning population may be important. The implications of this could be investigated.

The issue of shifting baselines is a real one in models that constantly update MSY-related reference points (or for which environmental conditions are changing). Whether or not the issue is of importance depends on the interplay between the HCR and reference point definitions, especially the degree of precaution built in to the framework, and the way in which the assessment is implemented and uncertainty estimated. The formal way of evaluating the robustness of the approach is through MSE. In the absence of MSE, and with the potential for constantly changing assessments, it is hard to intuit whether there is any potential problem as expressed by Oceana. These issues are also noted under ToR (d). However, as noted under ToR (d), the management system is generally highly precautionary, providing for a conservative OFL, especially given assumptions regarding stock-recruitment steepness, ABC less than the OFL to account for uncertainty, TACs set lower than ABC even on a single species basis, the 2 million tonne groundfish cap, and other provisions. The MSE work reported under ToR (d) includes the current HCR, setting TACs equal to the ABC from application of the current assessment into the future (with feedback). The $B_{20\%}$ rule appears from that evaluation to provide strong protection of pollock as forage at an apparent high cost to the fishery, in terms of closure frequency and overall reduction in yield. From that work, at least as considered during review, there does not appear to be any major issue with the framework applied.

ToR f *Recommendations for further assessment improvements for management in both the long and short term.*

As stated throughout this review, a harvest strategy is more than a HCR. Even from a restricted scientific perspective, it is at least the set of interacting data provision, assessment and forecasting, and HCR aspects. The same HCR may be more or less effective at meeting management objectives when informed by a different, or inconsistent, assessment. Even a consistently applied assessment may fail if data inputs are not as assumed. Data flows may be disrupted by application of the HCR.

Overall, therefore, it is important to ensure that all aspects of the strategy work effectively and consistently. From the foregoing sections, it seems that the EBS pollock strategic framework has been applied consistently and effectively since the late 1990s. In that time, consistent, high quality data provision has occurred for use with a reasonably consistent stock assessment used to inform a standardised harvest strategy Tier framework (and using Tier 1 for pollock). Throughout, wider issues have been considered when setting TACs and other controls and the overall harvest strategy has therefore continuously updated, even as the core, single species "engine" has ticked over.

As outlined in foregoing sections, there may be some issues to attend to relating to ageing or specifics of inputs such as natural mortality at age or steepness of the stock-recruit relationship. Similarly, there may be some issues to explore in the assessment, notably relating to treatment of ageing error, how selectivity is forecast and how results are communicated. There may also be issues that could affect the overall strategy, such as climate change and productivity decline that will require careful consideration of future alternative control rules.

The most pressing issue, however, appears to be the need for evaluation of the full current strategy (data, assessment, Tier system) to investigate how as a whole it will perform if the ESA over-ride rule is triggered. There is a real risk that triggering the rule will create severe problems with the strategy as applied for the last decade as it will change data flows to the assessment and hence, potentially, the reliability of assessment outputs that currently underpin Tier 1 application. If Tier 1 application is compromised, the HCR will change. No evaluation (i.e. MSE) has been performed to look critically at how the system will operate in these circumstances. Given work already undertaken to develop a spatial assessment, which could alternatively be used as a spatial operating model, and MSE work undertaken to consider climate change implications, the wherewithal for MSE work directed nearer-term already exists. It is **recommended** that this is the most pressing activity at this time.

CONCLUSIONS AND RECOMMENDATIONS

Because of the wide scope and lack of review time, it is highly likely that misinterpretation of some materials has been made. This is the fault of the reviewer, not of the many excellent AFSC scientists who gave good presentations and made the review an enjoyable experience – to them, many thanks. The AFSC is in the enviable position of having many very good people doing good work and providing good support to the NPFMC.

Notwithstanding, the review was arguably too wide in scope to do justice to any one element. There remains a need to review in detail the stock assessment, with close attention to how well it can consistently provide a credible basis for application of the Tier 1 harvest strategy. This is especially important when the pollock biomass is estimated to be close to the $B_{20\%}$ trigger for cessation of directed fishing. If cessation of directed fishing is triggered, continued Tier 1 usage could be undermined. Limited MSE work to date has concentrated on the implications of climate change but would be more usefully directed at evaluating the performance of the current harvest strategy in response to changing data availability triggered by the sea lion over-ride rule. This activity is seen as the most important at this time.

Specific recommendations are highlighted in **bold, red** in the preceding sections.

APPENDIX 1

BIBLIOGRAPHY

Prior to the Workshop, extensive materials were provided *via* a dedicated website site (**http://tinyurl.com/2b9ddg4** ; see also a list of documents at Appendix 2, Annex 3,below). The materials are too numerous to catalogue here but were extensive and comprehensive, and relevant to all terms of reference in varying degrees.

During the workshop nineteen (19) presentations were given, and additional materials were provided on request. The presentations were made available using the dedicated website which was accessed using guest Wi-Fi throughout the meeting. Directory listings are provided below for completeness.

Directory listing of presentations:

01/07/2010 10:57 a.m.	92,160	age_err.ppt
29/06/2010 09:22 p.m.	11,692,900	Assmnt_1_CIE.pptx
28/06/2010 05:09 p.m.	1,679,872	Canino_2010.ppt
29/06/2010 06:36 a.m.	5,159,540	CIE 1.pptx
24/06/2010 02:32 p.m.	54,933,504	CIE Review - Taina - 28 June 2010.ppt
30/06/2010 09:14 a.m.	36,016,640	CIE-Taina-Review June 28 2010_fin.ppt
29/06/2010 03:24 p.m.	81,932,288	CIE_acoustic.ppt
29/06/2010 11:39 a.m.	2,232,832	CIE_Assmnt_AgeCompEtc.ppt
29/06/2010 09:24 p.m.	26,895,872	CIE_Aydin.ppt
30/06/2010 03:50 a.m.	10,509,824	CIE_CoopRes_Barbeaux.ppt
29/06/2010 02:17 p.m.	6,409,216	CIE_Econ_2010.ppt
30/06/2010 03:55 a.m.	6,706,128	CIE_econ_research.pptx
30/06/2010 07:00 a.m.	2,285,568	CIE_mgt_council.ppt
30/06/2010 05:59 a.m.	6,662,656	CIE_Observer_2010.ppt
30/06/2010 03:59 a.m.	7,677,440	CIE_Pred_Prey.ppt
29/06/2010 05:26 p.m.	3,761,048	CIE_Salmon_bycatch.pptx
29/06/2010 09:00 a.m.	4,544,000	CIE_TrawlSurvey_EBSPollock.ppt
29/06/2010 06:35 a.m.	4,893,696	EBSpoll_Age_Growth_CIE2010.ppt
01/07/2010 11:01 a.m.	9,272,901	HarvestStrat.pptx

Directory listing of other files provided during meeting:

09/07/2010 09:48 a.m.	291,718	Fs and SER.xlsx
09/07/2010 09:48 a.m.	757,851	MSC-BSAIPollockRecertReptp86.pdf
09/07/2010 09:48 a.m.	756,666	MSC-BSAIRecertReptpage81.pdf
30/06/2010 03:54 a.m.	69,222	OCEANA_Letter_to_NPFMC_pollock_Dec_09.pdf
22/04/2008 01:13 p.m.	984,004	De_Robertis_et_al -- EBS_Vessel_Comparison_2008 ICESJMS.pdf
04/05/2010 03:10 p.m.	2,987,957	De_Robertis_et_al -- Multifreq_IN PRESS_CJFAS.pdf
24/04/2008 09:47 a.m.	553,933	De_Robertis_Williams -- Length_Weight_2008 TAFS.pdf
01/03/2006 05:24 p.m.	280,130	De_Robertis_Wilson -- Pollock_avoid_trawling_vessels_2006_ICESJMS.pdf
14/06/2010 10:59 a.m.	576,691	De_Robertis_Wilson -- Silent_ships_part-1_2010_ICESJMS.pdf
14/06/2010 10:58 a.m.	425,958	De_Robertis_Wilson -- Silent_ships_part-2_2010_ICESJMS.pdf
24/06/2010 10:26 a.m.	4,429,063	DRAFT -- Honkalehto_et_al_Acoustics from fishing vessels_INT-REVIEW_June24.pdf
25/06/2010 12:04 p.m.	436,065	DRAFT -- Williams_et_al --Net Selectivity_SUBMITTED_ICESJMS.pdf
16/06/2010 02:30 p.m.	1,709,603	DRAFT--Honkalehto et al -- 2009 EBS shelf_AFSC Proc Rept.pdf
24/06/2010 03:46 p.m.	1,755,385	Honkalehto et al -- EBS shelf _2007_Tech Memo.pdf
14/09/2009 07:00 a.m.	256,427	Mann_Wilson_et al -- Pollock hearing_2009 TAFS.pdf
24/06/2010 03:43 p.m.	1,126,505	McKelvey -- 2009 Bogolsof AFSC_2009 Proc Rept.pdf
12/04/2007 08:37 a.m.	453,686	Walline -- EBS pollock spatial distribution, simulations 2007 ICESJMS.pdf

APPENDIX 2

Attachment A: Statement of Work for Dr. Kevin Stokes

External Independent Peer Review by the Center for Independent Experts

Eastern Bering Sea Pollock Stock Assessment and Management Methods

Scope of Work and CIE Process: The National Marine Fisheries Service's (NMFS) Office of Science and Technology coordinates and manages a contract providing external expertise through the Center for Independent Experts (CIE) to conduct independent peer reviews of NMFS scientific projects. The Statement of Work (SoW) described herein was established by the NMFS Project Contact and Contracting Officer's Technical Representative (COTR), and reviewed by CIE for compliance with their policy for providing independent expertise that can provide impartial and independent peer review without conflicts of interest. CIE reviewers are selected by the CIE Steering Committee and CIE Coordination Team to conduct the independent peer review of NMFS science in compliance the predetermined Terms of Reference (ToRs) of the peer review. Each CIE reviewer is contracted to deliver an independent peer review report to be approved by the CIE Steering Committee and the report is to be formatted with content requirements as specified in **Annex 1**. This SoW describes the work tasks and deliverables of the CIE reviewer for conducting an independent peer review of the following NMFS project. Further information on the CIE process can be obtained from www.ciereviews.com.

Project Description: The Alaska Fisheries Science Center (AFSC) requests a Center of Independent Experts (CIE) review of stock assessments for the Eastern Bering Sea pollock stock assessment and management. The pollock fishery is large and the species involved is a key component of the ecosystem. The population dynamics characteristics and central role in North Pacific groundfish fisheries justify the need for periodic review of the scientific approaches for assessment and recommendations for management. Recent research projects studied movements, stock structure and reproductive ecology of pollock. The Bering Sea Integrated Ecosystem Research Program (BSIERP) funded a management strategy evaluation component that has the potential for guiding changes if needed in current management practices. A CIE review will provide timely feedback to these studies, and will be useful for the management of the Eastern Bering Ecosystem and fisheries. The ToRs of the peer review are attached in **Annex 2**. The tentative agenda of the panel review meeting is attached in **Annex 3**.

Requirements for CIE Reviewers: Three CIE reviewers shall conduct an impartial and independent peer review in accordance with the SoW and ToRs herein. CIE reviewers shall have working knowledge and recent experience in the application of stock assessment, including population dynamics, separable age-structured models, harvest strategies, survey methodology, and the AD Model Builder programming language. They should also have experience conducting stock assessments for fisheries management. Each CIE reviewer's duties shall not exceed a maximum of 14 days to complete all work tasks of the peer review described herein.

Location of Peer Review: Each CIE reviewer shall conduct an independent peer review during the panel review meeting tentatively scheduled at the Alaska Fisheries Science Center in Seattle, Washington during 28 June through 2 July 2010.

Statement of Tasks: Each CIE reviewers shall complete the following tasks in accordance with the SoW and Schedule of Milestones and Deliverables herein.

Prior to the Peer Review: Upon completion of the CIE reviewer selection by the CIE Steering Committee, the CIE shall provide the CIE reviewer information (full name, title, affiliation, country, address, email) to the COTR, who forwards this information to the NMFS Project Contact no later the date specified in the Schedule of Milestones and Deliverables. The CIE is responsible for providing the SoW and ToRs to the CIE reviewers. The NMFS Project Contact is responsible for providing the CIE reviewers with the background documents, reports, foreign national security clearance, and other information concerning pertinent meeting arrangements. The NMFS Project Contact is also responsible for providing the Chair a copy of the SoW in advance of the panel review meeting. Any changes to the SoW or ToRs must be made through the COTR prior to the commencement of the peer review.

Foreign National Security Clearance: If the panel review meeting is conducted at a government facility, the NMFS Project Contact is responsible for obtaining the Foreign National Security Clearance approval for CIE reviewers who are non-US citizens. For this reason, the CIE reviewers shall provide requested information (e.g., first and last name, contact information, gender, birth date, passport number, country of passport, travel dates, country of citizenship, country of current residence, and home country) to the NMFS Project Contact for the purpose of their security clearance, and this information shall be submitted at least 30 days before the peer review in accordance with the NOAA Deemed Export Technology Control Program NAO 207-12 regulations available at the Deemed Exports NAO website: http://deemedexports.noaa.gov/sponsor.html).

Pre-review Background Documents: Two weeks before the peer review, the NMFS Project Contact will send (by electronic mail or make available at an FTP site) to the CIE reviewers the necessary background information and reports for the peer review. In the case where the documents need to be mailed, the NMFS Project Contact will consult with the CIE Lead Coordinator on where to send documents. CIE reviewers are responsible only for the pre-review documents that are delivered to the reviewer in accordance to the SoW scheduled deadlines specified herein. The CIE reviewers shall read all documents in preparation for the peer review. The list of documents and background papers are provided at the end of this document

Panel Review Meeting: Each CIE reviewer shall conduct the independent peer review in accordance with the SoW and ToRs, and shall not serve in any other role unless specified herein. **Modifications to the SoW and ToRs can not be made during the peer review, and any SoW or ToRs modifications prior to the peer review shall be approved by the COTR and CIE Lead Coordinator.** Each CIE reviewer shall actively participate in a professional and respectful manner as a member of the meeting review panel, and their peer review tasks shall be focused on the ToRs as specified herein. The NMFS Project Contact is responsible for any facility arrangements (e.g., conference room for panel review meetings or teleconference arrangements). The NMFS Project Contact is responsible for ensuring that the Chair understands the contractual role of the CIE reviewers as specified herein. The CIE Lead Coordinator can contact the Project Contact to confirm any peer review arrangements, including the meeting facility arrangements.

Contract Deliverables - Independent CIE Peer Review Reports: Each CIE reviewer shall complete an independent peer review report in accordance with the SoW. Each CIE reviewer shall complete the independent peer review according to required format and content as described in Annex 1. Each CIE reviewer shall complete the independent peer review addressing each ToR as described in Annex 2.

Other Tasks – Contribution to Summary Report: Each CIE reviewer may assist the Chair of the panel review meeting with contributions to the Summary Report, based on the terms of reference of the review. Each CIE reviewer is not required to reach a consensus, and should provide a brief summary of the reviewer's views on the summary of findings and conclusions reached by the review panel in accordance with the ToRs.

Specific Tasks for CIE Reviewers: The following chronological list of tasks shall be completed by each CIE reviewer in a timely manner as specified in the **Schedule of Milestones and Deliverables**.

1) Conduct necessary pre-review preparations, including the review of background material and reports provided by the NMFS Project Contact in advance of the peer review.
2) Participate during the panel review meeting in Seattle, Washington during 28 June through 2 July 2010, as specified herein.
3) LOCATION and DATES as specified herein, and conduct an independent peer review in accordance with the ToRs (**Annex 2**).
4) No later than 16 July 2010, each CIE reviewer shall submit an independent peer review report addressed to the "Center for Independent Experts," and sent to Mr. Manoj Shivlani, CIE Lead Coordinator, via email to shivlanim@bellsouth.net, and CIE Regional Coordinator, via email to David Die ddie@rsmas.miami.edu. Each CIE report shall be written using the format and content requirements specified in Annex 1, and address each ToR in **Annex 2**.

Schedule of Milestones and Deliverables: CIE shall complete the tasks and deliverables described in this SoW in accordance with the following schedule.

17 May 2010	CIE sends reviewer contact information to the COTR, who then sends this to the NMFS Project Contact
7 June 2010	NMFS Project Contact sends the CIE Reviewers the pre-review documents
28 June – 2 July 2010	Each reviewer participates and conducts an independent peer review during the panel review meeting
16 July 2010	CIE reviewers submit draft CIE independent peer review reports to the CIE Lead Coordinator and CIE Regional Coordinator
30 July 2010	CIE submits CIE independent peer review reports to the COTR
6 August 2010	The COTR distributes the final CIE reports to the NMFS Project Contact and regional Center Director

Modifications to the Statement of Work: Requests to modify this SoW must be approved by the Contracting Officer at least 15 working days prior to making any permanent substitutions. The Contracting Officer will notify the COTR within 10 working days after receipt of all required information of the decision on substitutions. The COTR can approve changes to the milestone dates, list of pre-review documents, and ToRs within the SoW as long as the role and ability of the CIE reviewers to complete the deliverable in accordance with the SoW is not adversely impacted. The SoW and ToRs shall not be changed once the peer review has begun.

Acceptance of Deliverables: Upon review and acceptance of the CIE independent peer review reports by the CIE Lead Coordinator, Regional Coordinator, and Steering Committee, these reports shall be sent to the COTR for final approval as contract deliverables based on compliance with the SoW and ToRs. As specified in the Schedule of Milestones and Deliverables, the CIE shall send via e-mail the contract deliverables (CIE independent peer review reports) to the COTR (William Michaels, via William.Michaels@noaa.gov).

Applicable Performance Standards: The contract is successfully completed when the COTR provides final approval of the contract deliverables. The acceptance of the contract deliverables shall be based on three performance standards:
(1) each CIE report shall completed with the format and content in accordance with **Annex 1**,
(2) each CIE report shall address each ToR as specified in **Annex 2**,
(3) the CIE reports shall be delivered in a timely manner as specified in the schedule of milestones and deliverables.

Distribution of Approved Deliverables: Upon acceptance by the COTR, the CIE Lead Coordinator shall send via e-mail the final CIE reports in *.PDF format to the COTR. The COTR will distribute the CIE reports to the NMFS Project Contact and Center Director.

Support Personnel:

William Michaels, Contracting Officer's Technical Representative (COTR)
NMFS Office of Science and Technology
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Roger W. Peretti, Executive Vice President
Northern Taiga Ventures, Inc. (NTVI) 22375 Broderick Drive, Suite 215, Sterling, VA 20166
RPerretti@ntvifederal.com Phone: 571-223-7717

Key Personnel - NMFS Project Contact:
James Ianelli
NMFS Alaska Fisheries Science Center, 7600 Sand Point Way NE, Seattle, WA 98115
Jim.Ianelli@noaa.gov Phone: (206) 526-6510

William A. Karp, AKFC Science Director
National Marine Fisheries Service, NOAA, Alaska Fisheries Science Center
7600 Sand Point Way, NE, Bldg 4, Seattle, WA 98115
Bill.Karp@noaa.gov Phone: 206-526-4000

Annex 1: Format and Contents of CIE Independent Peer Review Report

1. The CIE independent report shall be prefaced with an Executive Summary providing a concise summary of the findings and recommendations, and specify whether the science reviewed is the best scientific information available.

2. The main body of the reviewer report shall consist of a Background, Description of the Individual Reviewer's Role in the Review Activities, Summary of Findings for each ToR in which the weaknesses and strengths are described, and Conclusions and Recommendations in accordance with the ToRs.

   a. Reviewers should describe in their own words the review activities completed during the panel review meeting, including providing a brief summary of findings, of the science, conclusions, and recommendations.

   b. Reviewers should discuss their independent views on each ToR even if these were consistent with those of other panelists, and especially where there were divergent views.

   c. Reviewers should elaborate on any points raised in the Summary Report that they feel might require further clarification.

   d. Reviewers shall provide a critique of the NMFS review process, including suggestions for improvements of both process and products.

   e. The CIE independent report shall be a stand-alone document for others to understand the weaknesses and strengths of the science reviewed, regardless of whether or not they read the summary report. The CIE independent report shall be an independent peer review of each ToRs, and shall not simply repeat the contents of the summary report.

3. The reviewer report shall include the following appendices:

   Appendix 1: Bibliography of materials provided for review
   Appendix 2: A copy of the CIE Statement of Work
   Appendix 3: Panel Membership or other pertinent information from the panel review meeting.

Annex 2: Terms of Reference for the Peer Review

Eastern Bering Sea Pollock Stock Assessment and Management Methods

CIE reviewers shall address the following Terms of Reference during the peer review and in the CIE reports.

a. Evaluation, findings, and recommendations on quality of input data and methods used to process them for inclusion in the assessment (specifically fishery and survey data).
b. Evaluation, findings, and recommendations on the level and adequacy of knowledge on pollock stock structure, biology, and life history.
c. Evaluation, findings, and recommendations of the analytical approach (application of a statistical ADMB integrated catch-age model) used to assess stock status and estimation/presentation of uncertainty including MSE approaches.
d. Evaluation, findings, and recommendations on the appropriateness of the harvest strategy used by the North Pacific Fishery Management Council (including uncertainty adjustments).
e. Evaluation, findings, and recommendations of whether harvest strategy is adequate within an ecosystem approach to management (e.g., bycatch, importance of pollock as forage).
f. Recommendations for further assessment improvements for management in both the long and short term.

Annex 3: Agenda—Eastern Bering Sea Pollock Stock Assessment and Management Methods

Alaska Fisheries Science Center
7600 Sand Point Way NE, Seattle, WA 98115Seattle, Washington
Week of June 14th 2010

Security and check-in:	Julie Pearce Julie.Pearce@noaa.gov	(206) 526 6547
Additional documents:	James Ianelli, Jim.Ianelli@noaa.gov	(206) 526 6510

Format will be from 9AM to 5PM each day with time for lunch and morning and afternoon breaks .

Monday, June 14th

1. **Informal meeting**
    a. Review of supplied documents

Tuesday, June 15th

Morning

2. **Preliminaries**
    a. Introductions
    b. Adopt agenda
    c. Overview of EBS pollock biology, fishery, and history of assessment

Afternoon

3. **Fishery independent data**
    a. Biological—stock structure, maturity, age and growth
    b. Groundfish survey data—abundance indices, age compositions
    c. Acoustic survey data—abundance indices, age compositions
    d. Research areas—alternative survey indices, opportunistic studies
    e. Food habits studies, multispecies modeling, BSIERP studies

Wednesday, June 16th

Morning

4. **Fishery data**
    a. Observer program overview Sampling protocols
    b. Catch accounting system
    c. Age composition estimation
5. **Assessment model**
    a. Catchabilities
    b. Likelihood formulations, data weighting
    c. Selectivity

Afternoon

    d. Spatial dynamics
    e. Natural mortality

Thursday, June 17th

6. **Management**
    a. Inseason practices
    b. Bycatch regulations and studies
    c.

7. Model alternatives/sensitivities

a. Alternative model runs, further discussion as needed

List of documents

Primary document

2009 SAFE report chapter: http://www.afsc.noaa.gov/REFM/docs/2009/EBSpollock.pdf

Supplemental documents

Ecosystem considerations: http://www.afsc.noaa.gov/REFM/docs/2009/ecosystem.pdf

Previous CIE review of EBS pollock (Stokes)

CIE review of Aleutian Islands pollock and Aleutian Islands atka mackerel.

Compilation of SSC and Plan Team comments on the assessments (extract from meeting reports)

Greenpeace review of assessment model (by Steve Martell, UBC)

Report from the EBS bottom trawl survey: recent methods and results.

Kastelle, C. R., and Kimura, D. K. 2006. Age validation of walleye pollock (*Theragra chalcogramma*) from the Gulf of Alaska using the disequilibrium of Pb-210 and Ra-226. e ICES Journal of Marine Science, 63: 1520e1529.

Kotwicki, S., T.W. Buckley, T. Honkalehto, and G. Walters. 2005. Variation in the distribution of walleye pollock (*Theragra chalcogramma*) with temperature and implications for seasonal migration. Fish. Bull 103:574–587.

Stahl, J., and G. Kruse. 2008a. Spatial and temporal variability in size at maturity of walleye pollock in the eastern Bering Sea. Transactions of the American Fisheries Society 137:1543–1557.

Stahl, J., and G. Kruse. 2008b. Classification of Ovarian Stages of Walleye Pollock (*Theragra chalcogramma*). In Resiliency of Gadid Stocks to Fishing and Climate Change. Alaska Sea Grant College Program • AK-SG-08-01.

Honkalehto, T., N. Williamson, D. Jones, A. McCarthy, and D. McKelvey. 2009. Results of the Echo Integration-Trawl Survey of Walleye Pollock (*Theragra chalcogramma*) on the U.S. and Russian Bering Sea Shelf in June and July 2007. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-194. http://www.afsc.noaa.gov/Publications/AFSC-TM/NOAA-TM-AFSC-194.pdf .

Background documents

Marine stewardship certification document.

Bycatch documents (Salmon EIS)

Bering Sea Integrated Ecosystem Research Plan

NMFS workshop report on natural mortality

Report from the 2009 workshop on spatial analyses and EBS pollock

NPFMC Fisheries management plan.

Bailey, K.M., T.J. Quinn, P. Bentzen, and W.S. Grant. 1999. Population structure and dynamics of walleye pollock, Theragra chalcogramma. Advances in Mar. Biol. 37:179-255.

Barbeaux, S. J., S. Gaichas, J. N. Ianelli, and M. W. Dorn. 2005. Evaluation of biological sampling protocols for at-sea groundfish observers in Alaska. Alaska Fisheries Research Bulletin 11(2):82-101.

Ianelli, J.N. and D.A. Fournier. 1998. Alternative age-structured analyses of the NRC simulated stock assessment data. In Restrepo, V.R. [ed.]. Analyses of simulated data sets in support of the NRC study on stock assessment methods. NOAA Tech. Memo. NMFS-F/SPO-30. 96 p.

Jurado-Molina J., P. A. Livingston and J. N. Ianelli. 2005. Incorporating predation interactions to a statistical catch-at-age model for a predator-prey system in the eastern Bering Sea. Canadian Journal of Fisheries and Aquatic Sciences. 62(8): 1865-1873.

Kimura, D.K., J.J. Lyons, S.E. MacLellan, and B.J. Goetz. 1992. Effects of year-class strength on age determination. Aust. J. Mar. Freshwater Res. 43:1221-8.

Moss, J.H., E.V. Farley, Jr., A.M. Feldmann, and J.N. Ianelli. (2009). Spatial distribution, energetic status, and food habits of eastern Bering Sea age-0 walleye pollock. Transactions of the American Fisheries Society.

Ressler, P. T. Honkalehto, R. Towler, amd C. Wilson. 2008. Using acoustic data from vessels of opportunity to estiimate walleye pollock abundance in the Eastern Bering Sea. ICES CIEM SEAFACTS International Symposium on the Ecosystem Approach. Bergen, Nor way, June 2008.

Swartzman, G.L., A.G. Winter, K.O. Coyle, R.D. Brodeur, T. Buckley, L. Ciannelli, G.L. Hunt, Jr., J. Ianelli, and S.A. Macklin (2005). Relationship of age-0 pollock abundance and distribution around the Pribilof Islands with other shelf regions of the Eastern Bering Sea. Fisheries Research, Vol. 74, pp. 273-287.

von Szalay PG, Somerton DA, Kotwicki S. 2007. Correlating trawl and acoustic data in the Eastern Bering Sea: A first step toward improving biomass estimates of walleye pollock (Theragra chalcogramma) and Pacific cod (Gadus macrocephalus)? Fisheries Research 86(1) 77-83.

Walline, P. D. 2007. Geostatistical simulations of eastern Bering Sea walleye pollock spatial distributions, to estimate sampling precision. ICES J. Mar. Sci. 64:559-569.

Wespestad, V. G., L. W. Fritz, W. J. Ingraham, and B. A. Megrey. 2000. On relationships between cannibalism, climate variability, physical transport, and recruitment success of Bering Sea walleye pollock (Theragra chalcogramma). ICES Journal of Marine Science 57:272-278.

Williamson, N., and J. Traynor. 1996. Application of a one-dimensional geostatistical procedure to fisheries acoustic surveys of Alaskan pollock. ICES J. Mar. Sci. 53:423-428.

APPENDIX 3

PERTINENT INFORMATION FROM THE REVIEW

1) Letter from Oceana
2) Steller sea lion case study (De Master, 2000)
3) Participants List

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December 7, 2009

Mr. Eric Olson, Chair
North Pacific Fishery Management Council
605 W. Fourth Avenue, Suite 306
Anchorage, AK 99501-2252

Mr. Doug Mecum, Regional Administrator
National Marine Fisheries Service
709 W. Ninth Street
Juneau, AK 99802-1668

RE: Agenda Item C-3 Groundfish Final Catch Specifications

Dear Chairman Olson and Mr. Mecum:

We remain concerned that the National Marine Fisheries Service and North Pacific Fishery Management Council are failing to ensure enough pollock remain in the Bering Sea to spawn, rebuild the pollock stock, provide prey for endangered Steller sea lions and Northern fur seals, and provide for an ecologically sustainable pollock fishery.

With the pollock spawning biomass at very low levels, the uncertainty that the biomass is at or below B20 must be fully evaluated. Fishing must stop if biomass is predicted to fall below 20% of the unfished spawning biomass of important Steller sea lion prey.[1] To comply with this provision, enough prey must be available during critical periods for sea lions, including during the winter. A spawning biomass of B20 is the proxy for the absolute minimum prey biomass, at any time, which can support Steller sea lions without causing jeopardy. However, it is uncertain whether NMFS is meeting these requirements. To date, NMFS has only reported a single point estimate of spawning biomass for sea lion prey stocks. This estimate is only applicable for the single calendar day for which it is estimated. The spawning biomass at all times of the year, including during the critical winter period, are not estimated, measured, or projected. There is considerable risk that pollock biomass is dropping below a level that causes jeopardy. To fully evaluate the risk of jeopardy, NMFS must include and account for estimates of spawning biomass throughout a calendar year, taking into account fishery removals, and should depict these estimates graphically.

Further, there is no generally accepted method for estimating unfished biomass, which provides the reference point for the B20 rule. Rather, the methods for estimating the unfished biomass vary among stock assessments. Different methods appear to be used depending on availability of data and convenience of fit to data. To date, NMFS has estimated unfished Eastern Bering Sea pollock biomass based on a stock recruitment relationship. This has resulted in a steadily lower shifting unfished biomass baseline, and lower associated B20 threshold. A more conservative approach may be to estimate the unfished biomass from average recruitment. In addition, estimates derived from average recruitment may be a more robust reference point in some cases.[2] To resolve this issue, B20 should be calculated using requirements similar to Amendment 56,

[1] *See* 50 C.F.R. § 679.20(d) (4).
[2] Haltuch, M.A., A.E. Punt, and M.W. Dorn. 2009. Evaluating the estimation of fishery management reference points in a variable environment. Fisheries Research (100): 42-56.

which evaluates scenarios based on several harvest scenarios and uses the management thresholds predicted from average recruitment.

Last year's stock assessment was markedly inaccurate in its predictions. This year's trawl survey, echo integration survey, fishery catch and resultant updated stock assessment now estimate the 2009 spawning biomass to have been 20% lower than was predicted (Table 1). While this estimate did fall within the lower bounds of the confidence intervals, the overestimation of spawning biomass over that last three years of declining abundance is cause for concern (Table 1).

Table 1: Decreases in spawning biomass estimates

		Hindsight change in current year's estimate of spawning biomass due to updated information
change in spawning biomass estimate from previous year's stock assessment	2009	-19.5%
	2008	-9.4%
	2007	-10.3%

We understand that predictive models are difficult to develop and that predictions may be marked with uncertainty. The stock assessment authors do caution that the Tier 1b harvest control rule results in extreme sensitivity to model uncertainty. Nonetheless, a review of assumptions within the model that may be causing an overestimation bias should be undertaken.

In addition, the fishing mortality on the prime ages of spawning pollock in the Eastern Bering Sea is well above the long-term average, which means that the remaining prime spawners of the stock are under extraordinary fishing pressure. For pollock aged six to nine, estimated fishing mortality is at the highest level observed in 31 years (Table 2).

Table 2: Percent of pollock age class removed by fishery

age class	**2009**	**mean 1978-2009**
1	0.0%	0.0%
2	0.3%	0.6%
3	3.7%	3.8%
4	**16.8%**	9.7%
5	**29.4%**	16.1%
6	**38.9%**	21.4%
7	**38.1%**	23.3%
8	**37.1%**	23.1%
9	**36.3%**	22.9%
10+	**18.0%**	13.1%

Table 2 is calculated from *October 2009 Plan Team Draft Assessment of the walleye pollock stock in the Eastern Bering Sea,* Table 1.20 *Estimates of numbers at age for the EBS pollock stock as estimated in 2009* and Table 1.21 *Assessment model-estimated catch-at-age of EBS* *pollock*. Shaded cells indicate age classes in 2009 whose fishing mortality was the highest observed in 31 years.

These larger, older pollock are the most fecund, productive age classes of pollock, which may be key to successful recruitment, and a diminishing proportion is able to survive the fishing season to spawn. A recent meta-analysis of 25 marine fish species, including pollock, showed strong maternal effects of larger and older fish on recruitment.[3] The winter pollock fishery harvests a sizable proportion of the remaining pollock spawners and will significantly diminish the contribution of quality spawners to recruitment.

The North Pacific Fishery Management Council needs better information to make an informed decision about the risks of current and proposed fishing activities on Steller sea lions and the Eastern Bering Sea pollock spawning biomass. Unless and until such information is brought forward, the NPFMC should authorize only the most conservative harvests of prey important to Steller sea lions in 2010.

We look forward to reviewing the forthcoming stock assessments, ecosystem considerations and biological opinion and working with you to maintain the health, productivity, and biodiversity of the North Pacific marine ecosystem while maintaining fishing opportunities and vibrant coastal communities.

Sincerely,

Jim Ayers,
Vice President, Oceana

[3] Venturelli, P.A., B.J. Shuter, and C.A. Murphy. 2008. Evidence for harvest-induced maternal influences on the reproductive rates of fish populations. Proc. R. Soc. B (276): 919-924.

Paper by De Master provided during review and scanned for completeness – reference unclear.

unfished stock size for 17 groundfish stocks combined was likely to be no more than 37.6 million tons (NMFS 2000), although it must be recognized that this figure represents an estimate of a hypothetical condition (i.e., the amount of groundfish biomass in the action area at this time had there been no commercial fishery ever prosecuted in this area). The estimated historical abundance of Steller sea lions (prior to their recent decline) is approximately 184,000 animals (Loughlin et al. 1984). The 1999 estimate of abundance for Steller sea lions from Winship (2000) is about 43,000 animals or roughly 23% of its historical carrying capacity, where annual consumption by sea lions in 1999 was estimated at 399,700 tons. Therefore, by analogy, 200,000 animals would be expected to eat approximately 1.71 million tons of forage annually. While crude, the estimated ratio of biomass consumed by 184,000 Steller sea lions to biomass of groundfish in an unfished environment is approximately 1:21. To interpret this estimate, it must be assumed that Steller sea lions only eat groundfish, which of course is a conservative assumption. With this assumption, it could be argued that a healthy population of Steller sea lions requires no more than 22 times as much forage as it is capable of consuming in a single year.

Another approach to estimating what the multiplier in going from prey consumed to prey available should be for a healthy marine mammal population was reported by Fowler (1999). The information reported in Fowler (1999) was extracted from Perez and McAlister (1993). Perez and McAlister reported that 32,000 Steller sea lions would consume 140,700 tons of forage. Extrapolating to the consumption of 184,000 Steller sea lions leads to a consumption estimate of 809,600 tons of forage. If it is again assumed that the unfished, equilibrium biomass of groundfish is 37.6 million tons, then the multiplier of groundfish forage available to Steller sea lions forage consumed is 46.

At present it is not possible to evaluate the relative merits of the two multipliers. Therefore, lacking alternatives, two approaches are proposed regarding the inference as to whether the current multiplier of forage available to forage consumption for a species listed under the ESA is indicative of a population that has adequate access to forage. One would be to use the average value of the two multipliers. In this case, that would be a multiplier of 34 (i.e., (22+46)/2). The other approach would be to use the more conservative estimate, as the ESA requires NMFS to err on the side of the animal when interpreting available data. The current ratio of biomass consumed by SSL to biomass available is 1:54 or a multiplier of 55. In either case, the current multiplier is greater than either of the two threshold values. This analysis, given uncertainties as discussed above, is therefore consistent with the conclusion that at the global or Action Area scale of the BSAI and GOA, Steller sea lions have adequate forage available to them to recover to optimal population levels.

Monthly estimates of prey availability for critical habitat

Average monthly estimates of biomass of pollock, Atka mackerel, and Pacific cod in critical habitat are

Month	Biomass (tons)	Month	Biomass (tons)
Jan	35,093	July	32,275
Feb	33,407	Aug	32,990
Mar	35,787	Sept	33,057
Apr	34,125	Oct	34,497
May	34,127	Nov	33,775
Jun	25,664	Dec	34,872

Table 2. Summary of biomass estimates of pollock, Pacific cod, and Atka mackerel in Critical Habitat (see NMFS 2000)

Month	Biomass (tons)	% Consumed	Month	Biomass (tons)	% Consumed
Jan	**6,012,615**	0.58	July	**2,183,687**	1.48
Feb	**6,383,644**	0.52	Aug	**2,538,000**	1.30
Mar	**6,397,301**	0.56	Sept	**3,083,889**	1.07
Apr	**5,961,198**	0.57	Oct	**3,750,186**	0.92
May	**3,851,215**	0.89	Nov	**4,456,918**	0.76
Jun	**2,056,445**	1.25	Dec	**5,100,096**	0.68

The analyses that we have conducted in this biological opinion suggests that competition as the result of an overall prey removal as allowed by the FMP does not adversely modify critical habitat. Rather, this analysis raises the following issues:

1. The abundance of any species in a particular space at a particular time is finite. Therefore, an activity that can remove hundreds of pounds in a single tow and thousands of tons of fish per day must, for short periods of time (hours to days), reduce the biomass of the targeted fish remaining in the immediate area. By extension, it is reasonable to assume that, as fishing effort increases or is concentrated in a particular area in a specific period of time, the extent and duration of those reductions would increase.

2. The likelihood of locally depleting a fish resource increases when that resource is patchily distributed. An assumption in our analyses suggested that the degree to which heterogeneity in the distribution of biomass occurs could confound the interpretation of forage availability in critical habitat for Steller sea lions. However, fish species are not

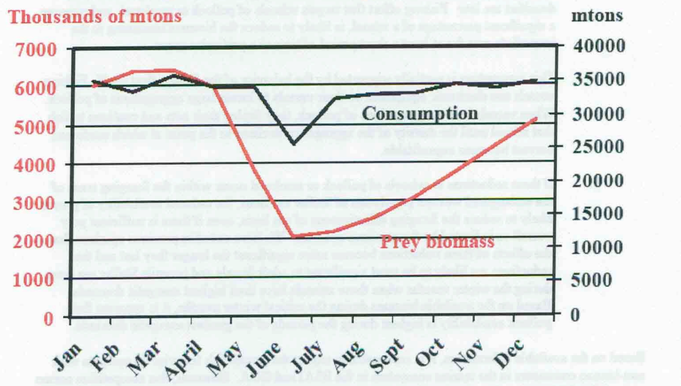
always homogeneously distributed throughout the water column. Instead, there are specific areas that have larger numbers of fish and other areas that have limited numbers of fish (Bakun 1996). Pollock and Atka mackerel are schooling fish that are patchily distributed, within a school their biomass is very high while outside of a school their densities are low. Fishing effort that targets schools of pollock or mackerel, and removes a significant percentage of a school, is likely to reduce the biomass remaining in the immediate area for at least a short period of time in a particular space.

This assumption is partially supported by the behavior of the fishing fleet itself. Fishing vessels use electronic equipment on their vessels to locate large aggregations of pollock. When vessels locate aggregations of pollock, they deploy their nets and continue to fish that school until the density of the aggregation declines to the point at which continued harvest becomes unprofitable.

3. If these reductions in schools of pollock or mackerel occur within the foraging areas of the endangered western population of Steller sea lions, the reduced availability of prey is likely to reduce the foraging effectiveness of sea lions, even if there is sufficient prey overall as indicated by the previous analyses. We have stated in previous opinions that the effects of these reductions become more significant the longer they last and the reductions are likely to be most significant to adult female and juvenile Steller sea lions during the winter months when these animals have their highest energetic demands. Based on the available biomass during the critical winter months, it is apparent that pollock availability is highest during the periods of the greatest energetic demands.

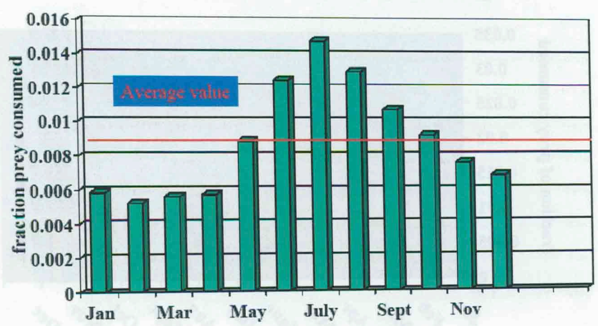
Based on the available information, it is reasonable to expect the groundfish fisheries do compete with non-human consumers in the marine ecosystem in the BSAI and GOA. However, this competition occurs as a result of the temporal and spatial behavior of the fishing fleet, and removals by this fleet on a local level, not as a result of a decrease in total prey availability due to the reduction of total fish biomass. Our current review is consistent with previous biological opinions that suggest that the harvesting ability of the fishing fleet and of individual vessels may deplete the groundfish biomass on small, spatial and temporal scales that would be expected to reduce the availability of groundfish to other, non-human consumers.

Steller Sea Lion Consumption versus Prey Availability in Critical Habitat



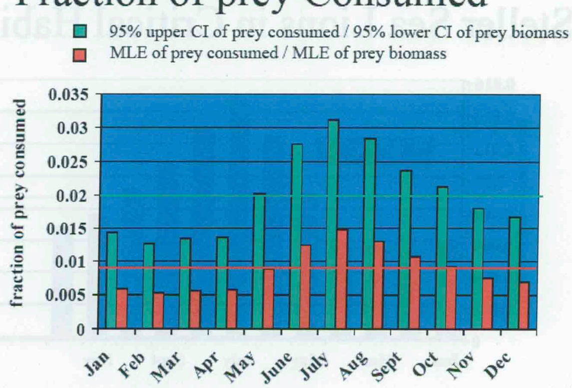
Biomass estimates of prey are for pollock, Pacific cod and Atka mackerel

Fraction of Prey Consumed by Steller Sea Lions in Critical Habitat



Biomass estimates of prey are for pollock, Pacific cod and Atka mackerel

Steller Sea Lion: Fraction of prey Consumed



Biomass estimates of prey are for pollock, Pacific cod and Atka mackerel

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